

Physics in the Fixed Target Areas

Erik Ramberg

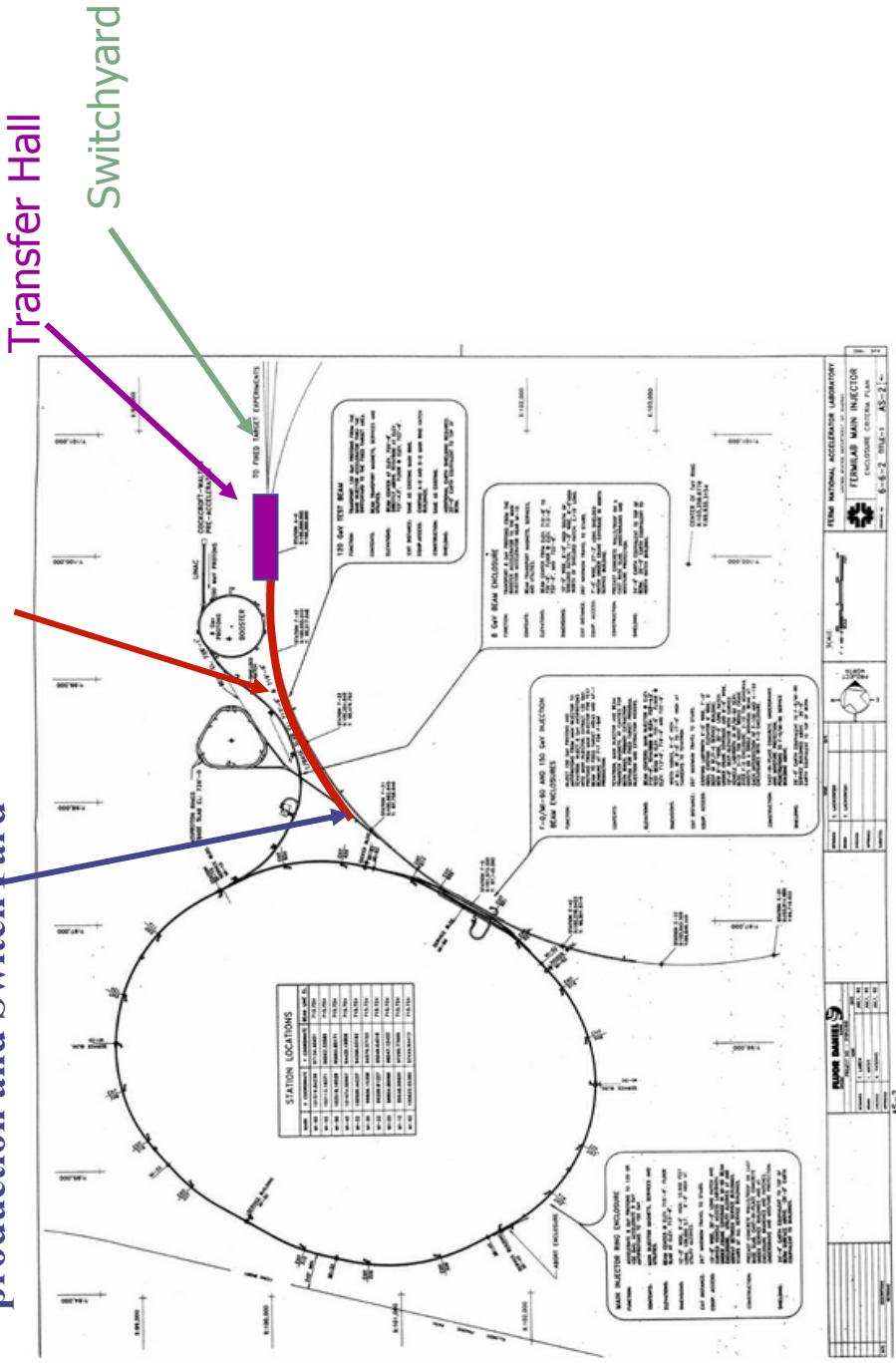
Users meeting / 2 June, 2004

- ◆ Beam delivery to Switch Yard
- ◆ Meson Beam Lines
 - MTest: the Meson Test Beam Facility
 - MCenter: MIAPP
 - ME: E906 – the Drell-Yan experiment
- ◆ Neutrino Beam Line
 - NM (KTeV): Charged Kaons at the Main Injector

The SwitchYard 120 project is complete and Main Injector proton beams are being delivered to experiments

Split between pbar production and SwitchYard

P2,P3 beamlines

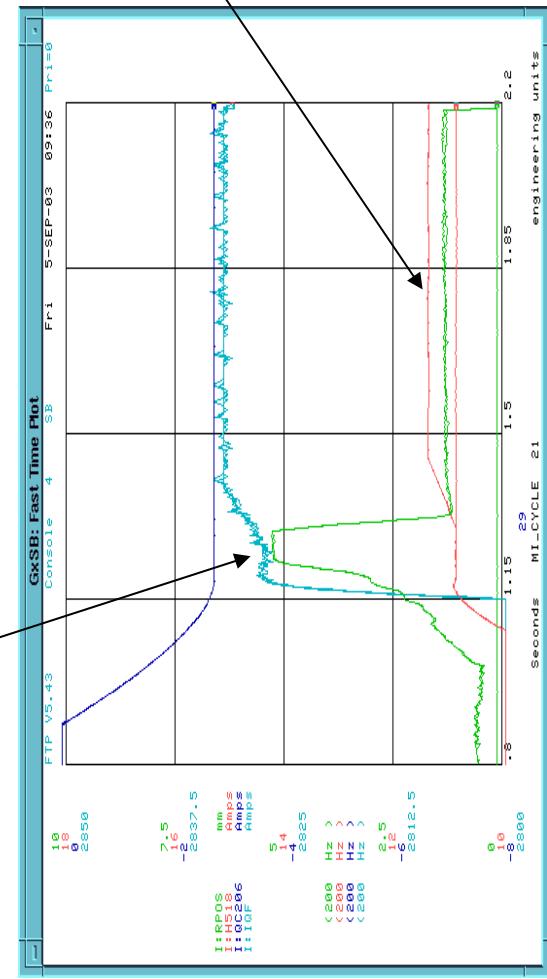


Slow Spill in SY120

- ❖ Currently have one 600 msec resonantly extracted slow spill every minute from a single batch in the MI (<5% effect on pbar production).
- ❖ More frequent spills are at the discretion of the crew chief.
- ❖ Accelerator Division is working on multi-batch extraction from the Main Injector – one batch to pbar with fast extraction, and one batch to SwitchYard, with resonant extraction.
- ❖ Maximum intensity of 2.5E12 pps - currently limited by losses in the Tevatron tunnel

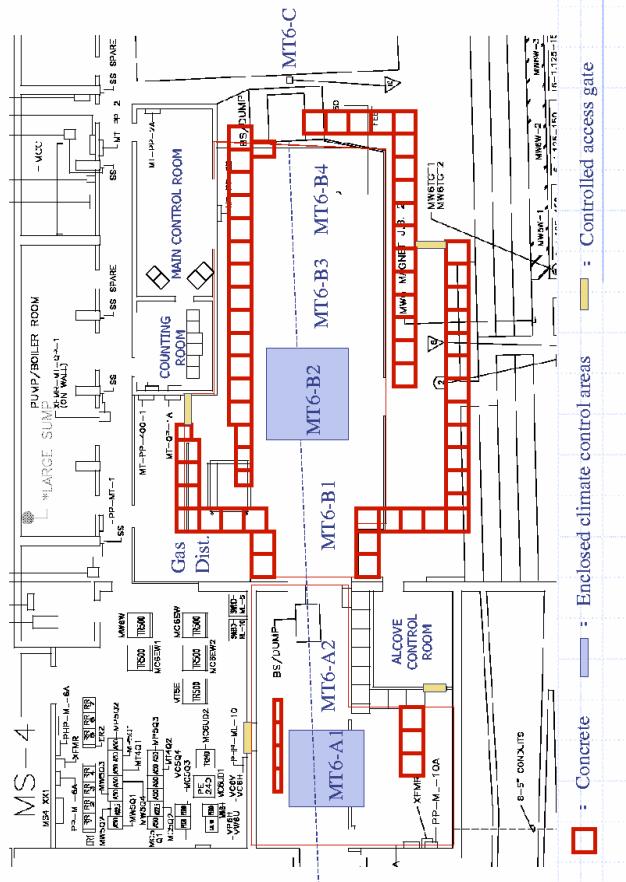
Pbar production: fast extraction on 1st batch

600 ms SY120 spill:
resonant extraction
on 2nd batch

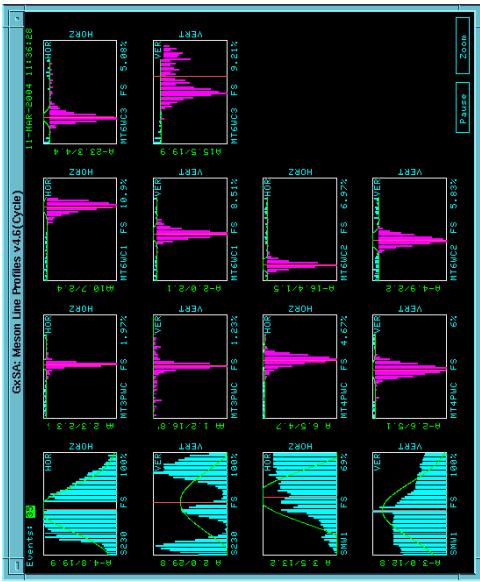


Meson Test Beam Facility

MT6 Test Beam User Areas



- Beam:
 - 120 GeV protons: >100,000 protons/spill
 - 66,33 GeV secondaries: ~1-10,000 /spill
 - Low energy muons: ~100 /spill
- User areas:
 - 6 user stations in two enclosures.
 - 2 air conditioned huts.
 - 2 separate control rooms.
 - Outside gas shed + inside gas delivery system can bring any 2 gases (and exhaust lines) to any of the user areas
- Beamline devices:
 - 2 Cerenkovs
 - 3 MWPC tracking chambers
 - 2X,2Y planes of silicon strips
 - DAQ



The friendly confines of Meson Lab



SWIC profiles while delivering 120
Gev beam (1 mm wire spacing)



BTeV pixel detectors in MT6A1 hut

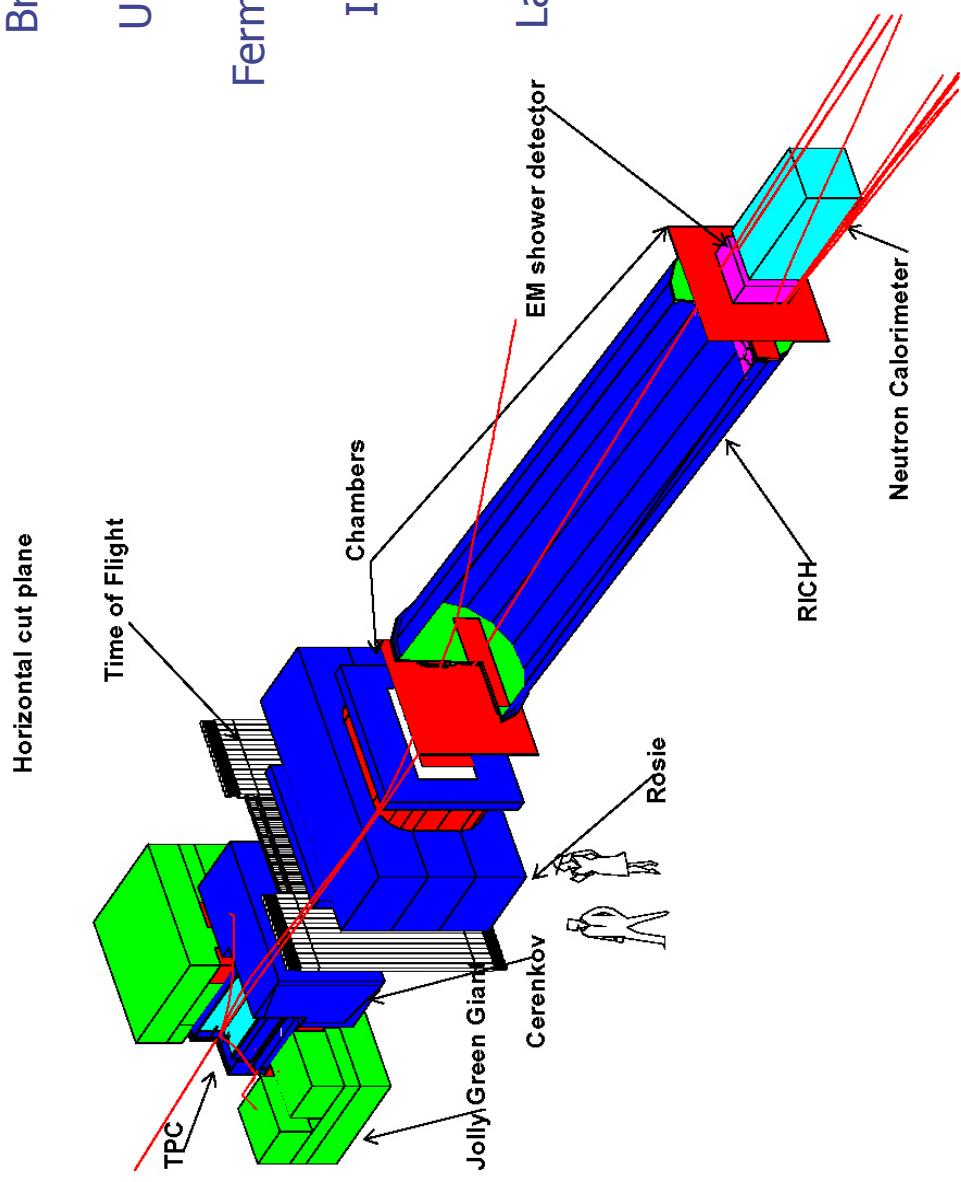
One of 3 MWPC facility tracking stations

List of MTBF Memoranda of Understanding (MOU):

- T926: RICE - Took data in Feb. - completed
- T927: BTev Pixel - Taking data now
- T930: BTev Straw - Taking data now
- T931: BTev Muon - Install over Summer
- T932: Diamond Detector - Taking data in Summer
- T933: BTev ECAL - Install over Summer
- T935: BTev RICH - Install this month and start taking data
- T936: US/CMS Pixel - Taking data now

MIPP

Main Injector Particle Production Experiment (FNAL-E907)



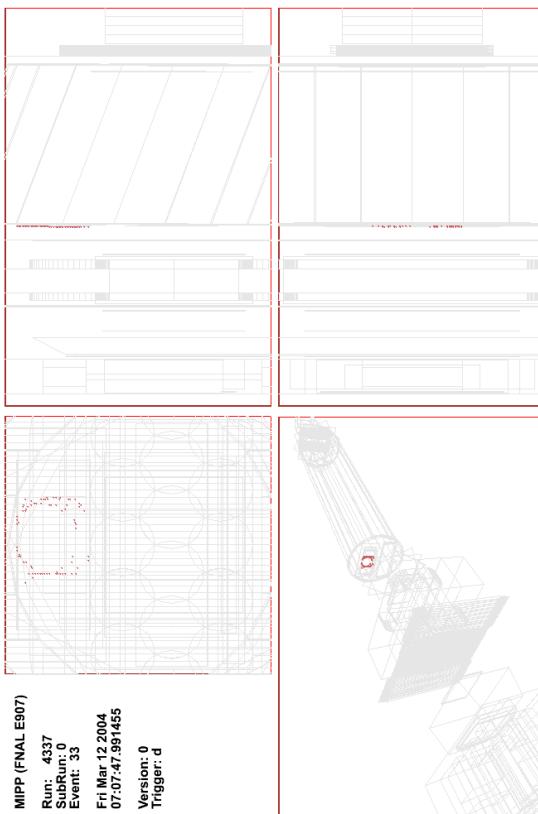
Brookhaven National Laboratory
IFI, University of Chicago
University of Colorado, Boulder,
Elmhurst College and EFI
Fermi National Accelerator Laboratory
Harvard University
Illinois Institute of Technology
University of Iowa
Indiana University
Lawrence Livermore Laboratory
University of Michigan
Purdue University
University of South Carolina
University of Virginia

50 collaborators
11 grad students
11 post docs

$>3\sigma$ P/K separation

Particle ID in MIPP

RICH being read out successfully. We see rings.

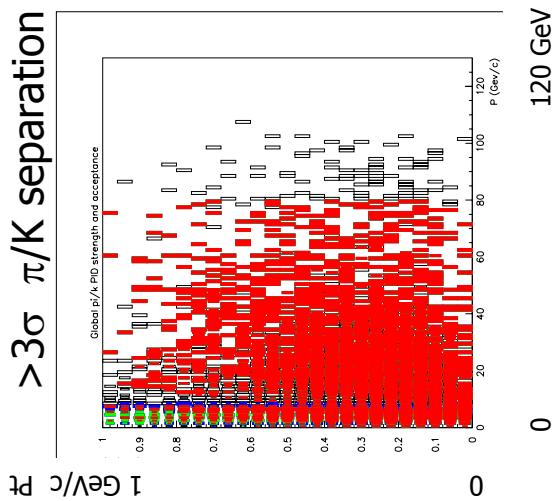


9

Rajendran Raja, All Experimenters Meeting, Fermilab

15-Mar-2004

$>3\sigma$ π/K separation



Physics Goals of E907-MIPP

- ◆ Particle Physics
 - Acquire unbiased high statistics data with complete id coverage for hadron interactions
 - Study non-perturbative QCD hadron dynamics, scaling laws of particle production
 - Investigate light meson spectroscopy, pentaquarks, glueballs
- ◆ Nuclear Physics
 - Investigate strangeness production in nuclei- RHIC connection
 - Nuclear scaling
 - Propagation of flavor through nuclei
- ◆ Misc. Measurements in Support of Other Programs
 - Atmospheric neutrinos – Cross sections of protons and pions on Nitrogen from 5 GeV- 120 GeV
 - Improve shower models in MARS, Geant4
 - Make measurements of production of pions for neutrino factory/muon collider targets
 - Proton Radiography- Stockpile Stewardship- National Security
 - MINOS target measurements – pion production measurements to control the near/far systematics

Plan to take:

- 1,330,000 one-second slow spills
- average of 1E10 protons/spill
- variety of targets
- 6 beam species (π^\pm , K^\pm , p^\pm)
- Secondary beam momenta of 5,15, 25,50, 70, 90 GeV/c on targets
- acquire 60 million events (18 million on liquid H₂)

Target	Physics	Data Points	Primary proton	Average Intensity/spill	Total number
Numi 1	MINOS	3.3		125000	2.06E+10
Numi 2	MINOS	3.3		125000	2.06E+10
H2	Scaling	6		9.76E+09	2.93E+15
N2	Atmospheric v	4		9.76E+09	1.95E+15
Be	pA	2		9.76E+09	9.76E+14
Be	Survey	1		9.76E+09	4.88E+14
C	Survey	1		9.76E+09	4.88E+14
Cu	pA	2		9.76E+09	9.76E+14
Cu	Survey	1		9.76E+09	4.88E+14
Pb	pA	2		9.76E+09	9.76E+14
Pb	Survey	1		9.76E+09	4.88E+14
Total		26.6			9.76E+15

Status of MIAPP: Consistently taking beam to commission detector and beamline



TPC is installed in Jolly Green Giant and operational.

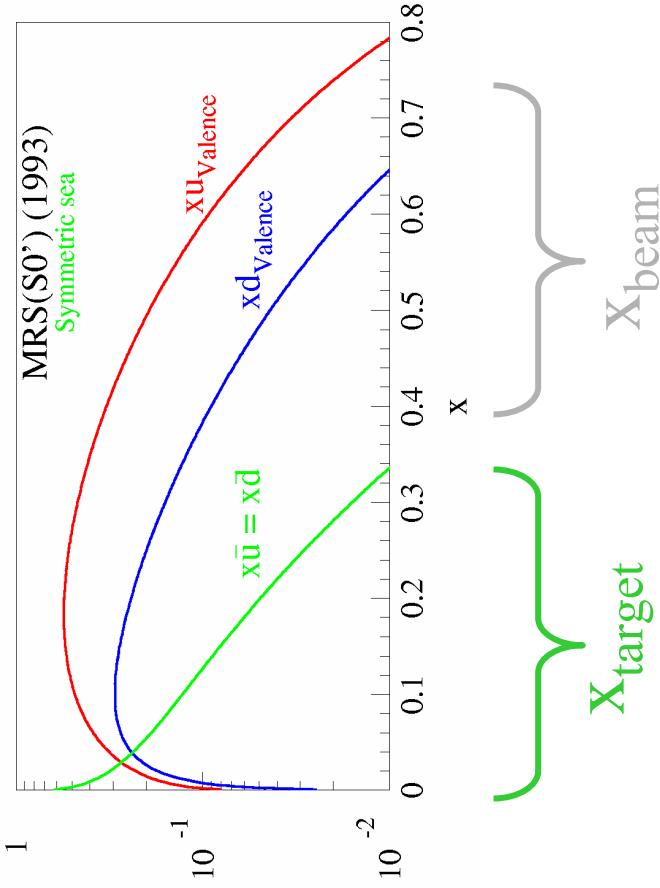
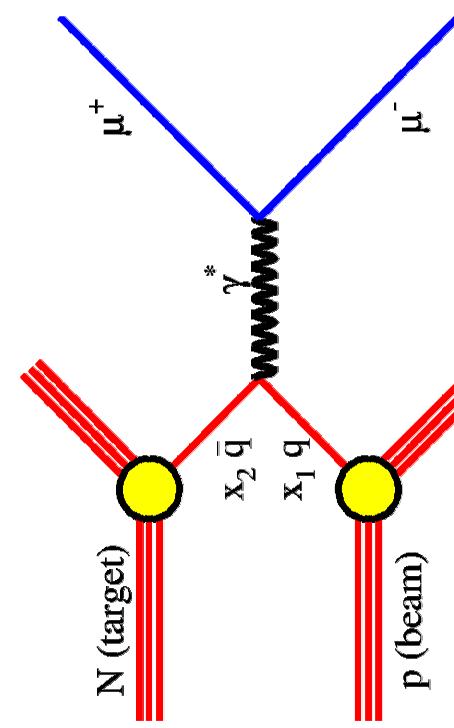


Experiment is in new enclosure of MC7



Photocathode of RICH sustained a fire. Detector is being reinstalled into the experiment with >75% of phototubes recovered.

Drell-Yan and Lepton Pair Physics at Fermilab: E906

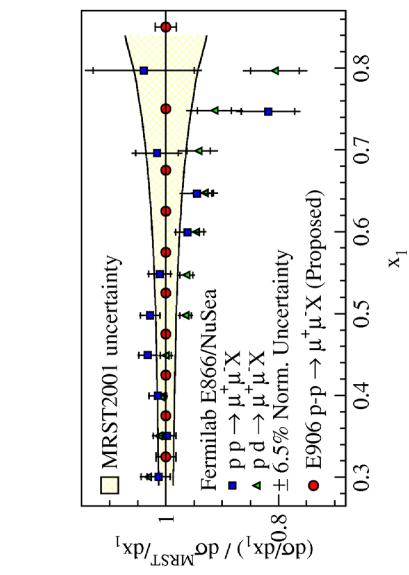


$$x_F \approx 2p_L/\sqrt{s} = x_1 - x_2$$

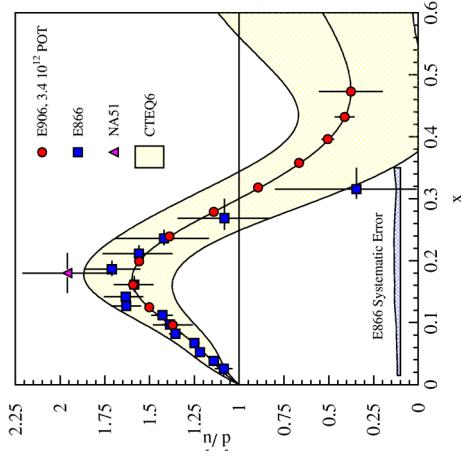
$$M_{\mu^+ \mu^-}^2 = s x_1 x_2$$

- Detector acceptance chooses range in x_{target} and x_{beam} .
- $x_F = x_{\text{beam}} - x_{\text{target}} > 0$
- High- x : Valence Beam quarks.
- Low- x : Sea quarks.

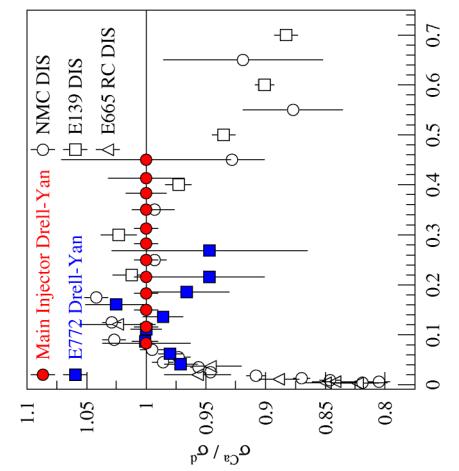
What is the structure of the nucleon and nucleonic matter?



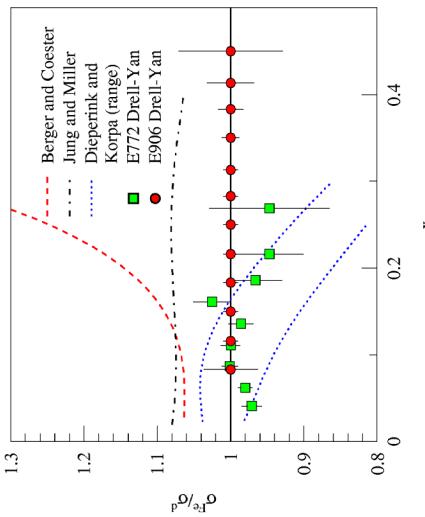
Parton distributions as $x \rightarrow 1$



d-bar/u-bar at intermediate- x



Is anti-shadowing a valence effect?



Where are the nuclear pions?

Advantages of E906:

E906 will use the 120 GeV MI beam, compared to the 800 GeV beam in predecessor E866:

$$\frac{d^2\sigma}{dx_1 dx_2} = \frac{4\pi\alpha'^2}{9x_1 x_2} \frac{1}{s} \times \sum_i e_i^2 [q_{ti}(x_t) \bar{q}_{bi}(x_b) + \bar{q}_{ti}(x_t) q_{bi}(x_b)]$$

- Cross section scales as **1/s**, thus will get 7x improvement
- Backgrounds, primarily from J/ ψ decays, scale as **s**, thus can improve luminosity by 7x

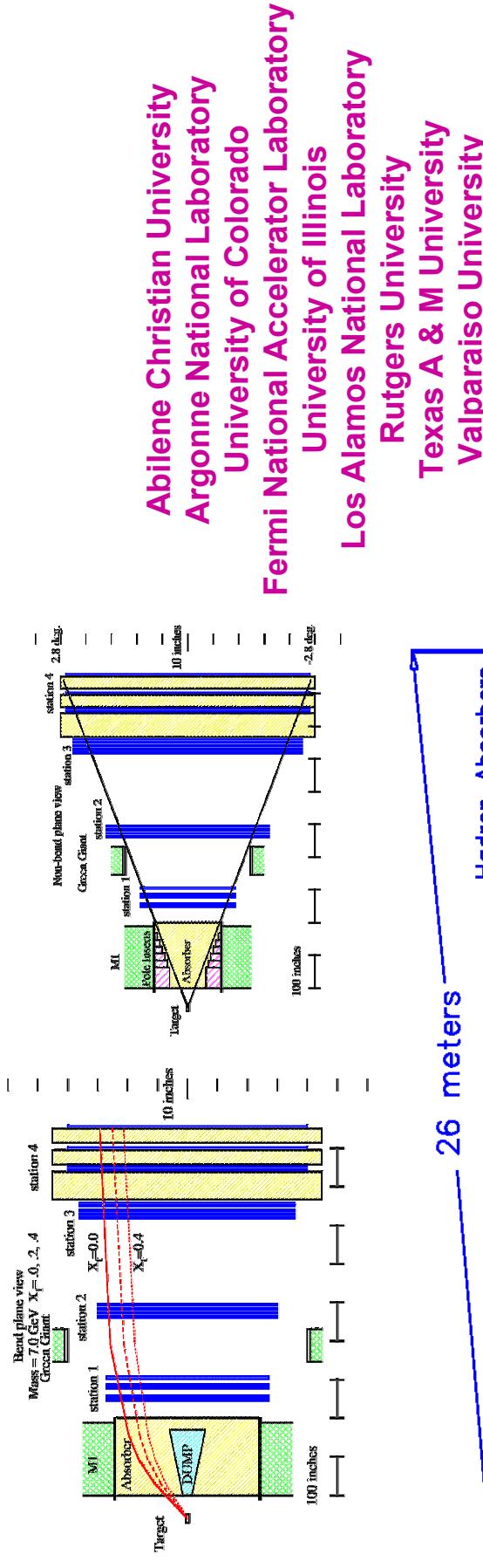
Disadvantages:

Lower energy particles mean:

- Lower boost implies reconfiguration of detector,
- Increased probability of hadron decay before absorber, and
- Greater multiple scattering of muons.

→ All can be handled in present detector design

E906 Detector and Collaboration



Schedule is now driven by funding profile

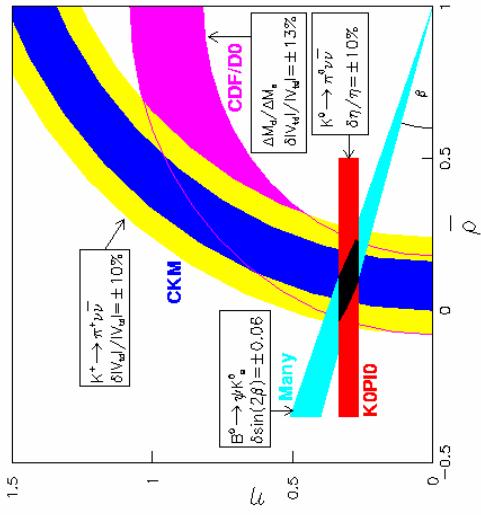
- \$2.1 M required for magnet and \$1 M for detector
- E906 construction starting in 2006 will allow for completion on an appropriate timescale—ready for beam in (early) summer 2009.
- *E906 will run earlier if funds are available earlier.*

A Charged Kaon Experiment at the Main Injector – How to proceed?

- **CKM(E921)** at Fermilab is an approved experiment to measure $\text{Br}[\text{K}^+ \rightarrow \pi^+ \nu \bar{\nu}]$ with ~ 100 signal events and < 10 background events in a high flux separated kaon beam at 22 GeV/c
- **P5** stops progress on CKM - Oct 2003
 - P5 judged *CKM to be an elegant world class experiment which based on present budgetary models should not proceed.*
- The collaboration is dealing with this impasse by developing a proposal to use an unseparated ~ 45 GeV/c beam in KTeV hall - **P940**
 - Demonstration of μMegas in NA48 → tracking in 230MHz tractable
 - Other 3 trackers unchanged (2 RICHES + Straws in vacuum)
 - Vetoing photons gets easier ($E_\pi^0 > 1 \text{ GeV} \rightarrow > 7 \text{ GeV}$)
 - Accidental backgrounds?

Measuring $|V_{td}|$ with $K^+ \rightarrow \pi^+ \bar{v}v$

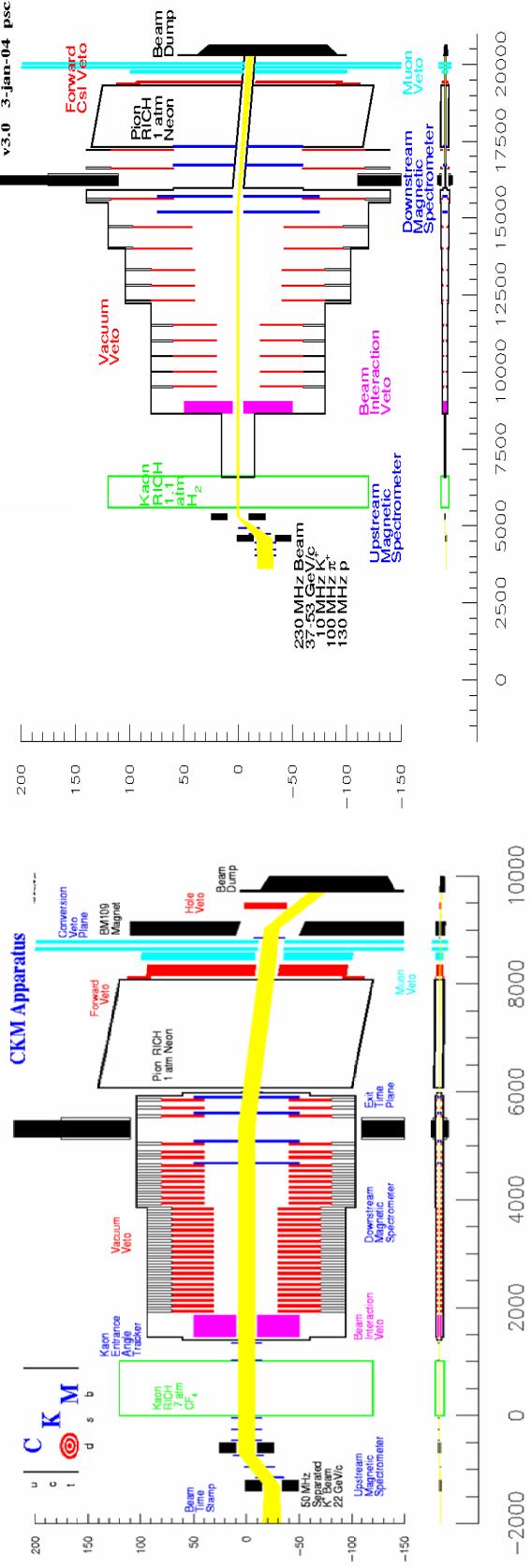
- $K^+ \rightarrow \pi^+ \bar{v}v$ is the best way to measure $|V_{td}|$ in the Standard Model
 - Theoretical uncertainties are small (m_{charm}) and robustly estimated. ($\sim 8\%$)
 - Structure of K^+ controlled by measurement, NO final state interactions.
 - New physics can easily show up in this mode due to dominance of loop diagrams
- Experimental Challenge
 - Need 100 signal events with < 10 background (6%) to match theory error.
 - $\text{Br}[K^+ \rightarrow \pi^+ v \bar{v}] = (8 \pm 1) \times 10^{-11}$ (Standard Model)
 - 3 clean events seen in BNL787 / 949 ($\text{Br} = 15^{+13}_{-9} \times 10^{-11}$)
- The tyranny of tiny decay rates
 - 100 events / $10^{-10} (\text{Br}) / 1\% (\text{acc}) = 10^{14}$ K decays
 - $10^7 \text{ sec/year} \rightarrow 10^7 \text{ } K \text{ decay/sec}$ to see 100 in 1 year
 - Need to control background to 10^{-11} of all K^+ decays



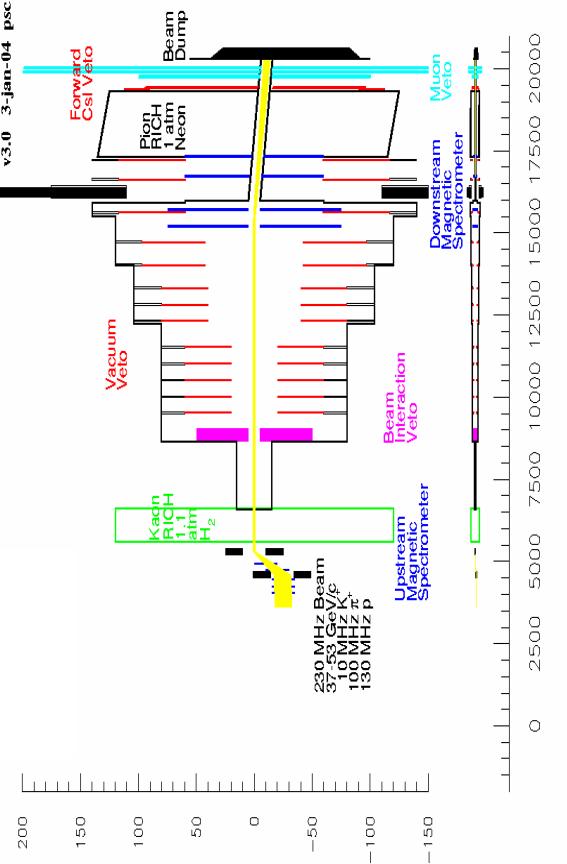
Apparatus

- Decay in flight
- Redundant high rate detectors and veto systems.

(E921) Separated K⁺ beam at 22 GeV/c:



(P940) Unseparated + beam at 37-53 GeV:



Located in MP9 building

Can be located in KTeV building

Our plan

- We are in the middle of this redesign now – we need to:
 - Complete the unseparated beamline design for NM2
 - Assess KABES feasibility in a 230 MHz beam
 - Re-evaluate backgrounds from Kaon interaction in detectors
 - Estimate backgrounds from non-kaon interaction accidents
 - Evaluate PNIN2 cuts, acceptance and backgrounds
 - Re-assess losses from deadtime, reconstruction, ...
- Once this technical work is complete:
 - Have external technical review of the redesign (a-la CKM)
 - Return to Fermilab and the PAC with a vetted re-design
 - Time scale of months